The Tomographic Hydrogen Emission Observatory (THEO): A CubeSat Mission to Investigate Earth's Extended Geocorona

Completed Technology Project (2015 - 2019)

Project Introduction

The proposed Tomographic Hydrogen Emission Observatory (THEO) mission is designed to investigate the physical mechanisms that control the production and loss of atomic hydrogen (H) in the outermost layer of the terrestrial neutral atmosphere known as the exosphere. Although the thermal evaporation of gaseous planetary atmospheres into space is a ubiquitous process in the universe, it is complicated at Earth by the strong charge exchange coupling between exospheric H atoms and ionospheric, magnetospheric, and solar wind ions. This ion-neutral coupling serves to enhance the permanent gravitational escape of exospheric H while dissipating plasma energy, particularly during geomagnetic storms. Studies of the Earth's exosphere thus address key NASA goals of assessing long-term changes in atmospheric composition as well as understanding the response of the terrestrial system to solar and geomagnetic energy input. In addition, accurate quantification of exospheric H is a crucial requirement for reliable remote sensing of the Earth's magnetospheric ring current via energetic neutral atom imaging. Despite the importance of Earth's H exosphere to the solar-terrestrial system, however, current understanding of its global structure and dynamical evolution is poor, such that the origin of significant discrepancies between measurements, models, and theory remains unresolved. Observation of solar ultraviolet (UV) radiation scattered by H atoms is a potential means to infer the underlying exospheric density distribution, but prior investigations have not provided sufficiently high-resolution, high-sensitivity, or global measurements to advance exospheric science. The proposed THEO mission is designed to overcome historical measurement limitations and significantly advance our understanding of H abundance and escape. The THEO mission concept is based on 3-D photometric sensing of ultraviolet H emission at 121.6 nm (Lyman-a) at unprecedented spatial resolution and angular coverage, along an ideal trans-lunar trajectory enabled by the EM-1 launch opportunity. THEO is designed to operate as a month-long, sounding-rocket mission, implementing a highly autonomous, three-axis-stabilized, 6U CubeSat platform, supported by a closed-loop ground-tracking system, orbit predictor, and redundant high-capacity ground stations. The THEO bus and science photometer share significant flight-heritage elements from the successful NSF CINEMA, USAF SENSE, and NASA POLAR satellite missions. The THEO bus includes operational redundancy for on-board elements, including the tracking transponder, the science data transmitter, and the electrical power subsystem. The operational flight software, heavily leveraged from the CINEMA mission, allows THEO to adapt to the instantaneous range-limited RF link capacity and to provide the first reliable means for quantifying global, 3-D H density from a vantage throughout and beyond the limits of the Earth's exosphere.

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Heliophysics Technology and Instrument Development for Science

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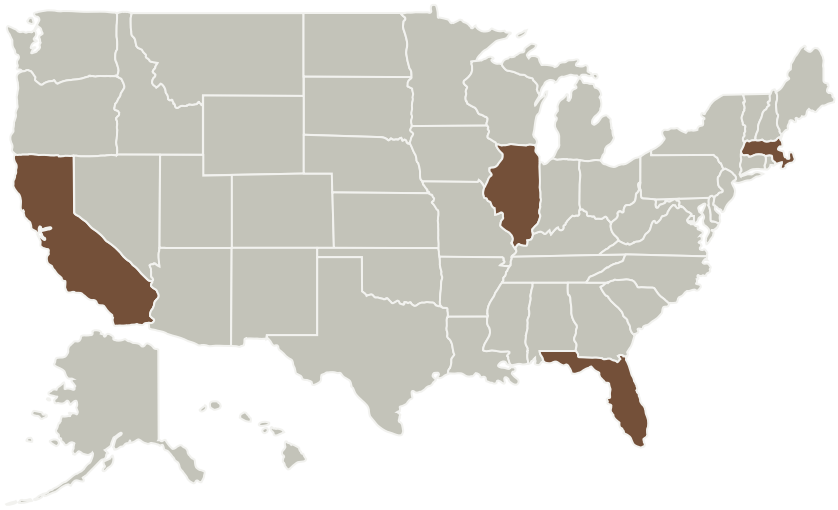
Primary U.S. Work Locations and Key Partners



Project Management

Program Director:

Roshanak Hakimzadeh

Program Manager:

Roshanak Hakimzadeh

Principal Investigator:

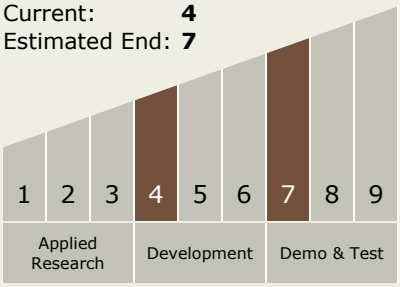
Lara Waldrop

Co-Investigators:

Richard A Doe
Scott Corum

Technology Maturity (TRL)

Start: **4**
Current: **4**
Estimated End: **7**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.4 Microwave, Millimeter-, and Submillimeter-Waves

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Organizations Performing Work	Role	Type	Location
Arecibo Observatory	Supporting Organization	US Government	Arecibo, Puerto Rico
Embry-Riddle Aeronautical University-Daytona Beach	Supporting Organization	Academia	Daytona Beach, Florida
Scientific Solutions	Supporting Organization	Industry	North Chelmsford, Massachusetts
SRI International	Supporting Organization	Industry	Menlo Park, California
UC Berkeley Space Science Laboratory	Supporting Organization	Academia	Berkeley, California
University of California-Berkeley(Berkeley)	Supporting Organization	Academia	Berkeley, California
University of Illinois at Urbana-Champaign	Supporting Organization	Academia	Urbana, Illinois

Primary U.S. Work Locations	
California	Florida
Illinois	Massachusetts

Target Destination

The Sun